

AD-A153 241 RESULTS FROM RADIATION MONITORING EQUIPMENT EXPERIMENT 1/1

1/1

RESULTS FROM RADIATION MONITORING EQUIPMENT CAPTIONED  
ON STS-8(U) AIR FORCE TECHNICAL APPLICATIONS CENTER

PATRICK AFB FL R G MADONNA ET AL. 09 JUL 84

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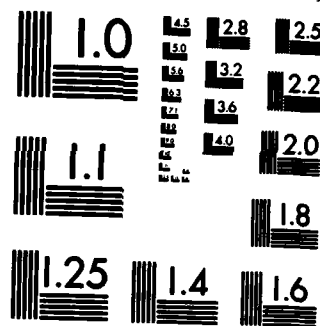
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RESULTS FROM RADIATION MONITORING  
EQUIPMENT EXPERIMENT ON STS-8



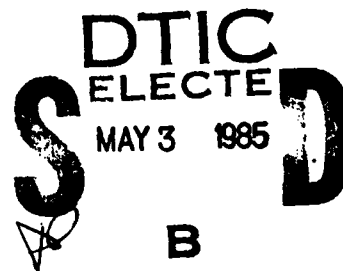
RICHARD G. MADONNA, ROSS L. AMICO, VIRGIL L. BROWN, AND  
VESTON R. KIDD

9 JULY 1984

FINAL REPORT.

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| <p>The results from the Radiation Equipment Monitoring (RME) experiment, flown onboard STS-8 are presented and discussed. The RME consists of the HRM-III gamma ray counter and PRM neutron/proton dosimeter. The gamma ray data agree with data from previous flights. Large increases in count rates are observed when the Orbiter is in the South Atlantic Anomaly. Neutron/proton dosage is consistent with NASA predictions for STS-8.</p> <p style="text-align: right;">... not required ...</p> |       |   |   |                           |
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# SUMMARY

The Radiation Monitoring Equipment (RME) was flown on STS-8 Space Shuttle Mission for the purpose of testing a concept for in-cabin, real-time crew dosimetry, and for the purpose of obtaining time resolved gamma-ray background data and neutron/proton background data. The RME consists of two instruments, EG&G HRM-III gamma-ray counter and EG&G Pocket REM Meter (PRM) neutron/proton dosimeter. The HRM-III was operated by the astronaut crew seven times during the mission, with each operation lasting 52.5 minutes. The PRM was operated twice during the mission with each operation lasting a minimum of ten hours.

The results from the HRM-III operations were plotted as a function of time and as a function of ground position. The data show large increases in count rate during the periods when the Orbiter was in the South Atlantic Anomaly. These data are consistent with data obtained from other missions.

The PRM results are displayed in tabular form. The average dose rate from these operations is  $.312 \pm .012 \text{ mrem/hr}$  ( $(2.49 \pm .013) \times 10^{-5} \text{ rad/hr}$ ). The total mission neutron/proton dosage predicted by these readings is approximately  $52.931 \text{ mrem}$  ( $4.224 \text{ mrad}$ ). This value is in agreement with NASA predictions for neutron/proton dosage for the STS-8 mission.

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## SECTION I INTRODUCTION

This report presents the results of the Radiation Monitoring Equipment (RME) experiment flown on STS-8. The objectives of the RME experiment are two-fold. The first objective was to exercise our ability to fly small non-space-specific hardware on the Space Shuttle. The RME tested the feasibility of using state-of-the-art dosimetry equipment that was not originally designed for orbital application for in-cabin, real-time crew dosimetry. The second objective of the experiment was to obtain time resolved gamma-ray background data and neutron/proton background data.

The first objective was partially met during the flight of STS-6 (ref 1). The RME was flown for the first time and a limited amount of data were taken. The quality of the data was sufficient to convince us that the instruments will work in space, and, more importantly, that the crew can operate them and obtain meaningful data. Longer operations were required to fully meet the first objective since the instruments were not utilized to their fullest extent during the STS-6 mission.

The second objective was also achieved, in part, during the STS-6 mission. The neutron/proton dosimeter, EG&G's Pocket REM Meter (PRM), was operated for sufficiently long periods of time and gathered meaningful background data. The gamma-ray counter, EG&G's HRM III, was only operated for 10 seconds each time it was activated and did not yield enough background data to meet the second objective.

STS-8 provided an opportunity to meet both objectives of the RME experiment. The HRM III was operated seven times with each operation lasting 52.5 minutes. The PRM was operated twice with each operation lasting a minimum of 10 hours.

## SECTION II

### EQUIPMENT

#### HRM-III.

The HRM-III (Figure 1) (ref 2) is a hand-held gamma-ray counter. It weighs approximately 1 kilogram (2.2 pounds) and is about the size of a small cassette recorder. The circuitry is all solid state and microprocessor controlled. The detector is a mecuric iodide ( $\text{HgI}_2$ ) crystal with a detection threshold of 100keV.

The HRM-III has 105 internal memories that can store counting data for playback at a later time. These memories are filled with the average counts obtained during a user determined time interval. The interval can vary from 1/3 of a second to 33 seconds. Playback of the stored data is accomplished through a liquid crystal display (LCD) on the HRM-III. This record-playback feature allows for a time-history of the gamma-ray counts without having a user continually monitoring the instrument. (For a more complete description of the HRM-III, see reference 2).

#### PRM.

The PRM (Figure 2) (ref 3) is a hand-held neutron/proton dosimeter. It weighs approximately 1 kilogram (2.2 pounds) and is somewhat larger than the HRM-III. The PRM has microprocessor-controlled solid-state circuitry. It uses three ionization tubes as detectors. These tubes are surrounded by a tissue equivalent plastic. The associated electronics then produces data in the form of counts, rads and rems in real time.

Data are obtained via an LCD. The PRM will read out either hours (elapsed time since turn-on), counts, rads, or rems just by changing the position of a rotary switch. The LCD displays the current value of the function (hours, counts, RADs, REMs) chosen and the LCD readout is updated as the value changes. Thus the PRM is a real time dosimeter. (For a more complete description, see reference 3).

#### Crew Training.

Crew training on the RME was accomplished at Patrick AFB, FL, in June 1983. Three of the crew were given a 2-hour briefing on the instruments and were allowed to operate them. Questions that the crew had on the operation of the instruments were answered at that time. The crew then practiced with the training units at Johnson Space Center.



## SECTION III

### RESULTS

#### HRM-III.

The HRM-III was operated seven times during the mission. Each operation lasted for 52.5 minutes. The HRM-III was setup to fill one memory every 30 seconds. In this configuration the HRM-III took data over approximately 58% of a 165 nautical mile (nm) (305.6 (km)) orbit.

The HRM-III performed well during STS-8. The only anomaly that occurred was during operation 4. (See Appendix). During the data readout and deactivation phase of operation 4, the crew reported that the display read "8888" and there was data in one channel only. This condition indicates a weak battery. The crew was advised to changeout the battery and reinitiate operation. The HRM-III functioned properly for all other operations.

The data obtained from the seven runs have been plotted two different ways. The first set of plots (Figures 3, 5, 7, 9, 11, 13, 15 and 17) show average counts per second plotted against time elapsed since instruments turn on. The second set of plots (Figures 4, 6, 8, 10, 12, 14, and 16) show the average counts per second plotted on a map of the world based on the Orbiter's subpoint. As an aide, the "unusual" numbering sequence for the operations, i.e., 3, 4a, 6, 7, and 8, corresponds to the numbers assigned by the crew during the flight. (See Appendix A).

The data plotted in Figures 3 through 17 show the background counts/second for gamma-rays. The data can clearly be divided into two categories: one for count rate in the South Atlantic anomaly; and the other for count rates outside of the South Atlantic anomaly. For data taken outside the South Atlantic anomaly, the background average count rate is 28 counts/sec. For data taken in the anomaly the average count rate goes as high as 265 counts/sec.

There is no easy way to convert these counts over to a dosage for gamma-rays. We are, however, currently exploring the possibility of modifying the PRM to include gamma-ray dosage with neutron/proton dosage.

No calibration is required for the HRM-III due to its use of solid state components and detector. The HRM-III that was flown had been checked by EG&G several months prior to STS-8.

In general, the data shows no surprises and appears consistent with previous measurements and expectations. Future flights will provide data from different altitudes and orbital inclinations thereby adding to the data base of background data.

#### PRM.

The PRM was operated twice during the STS-8 mission. The first operation occurred at Mission Elapsed Time (MET) 1/07:10:57 and lasted 15.44 hours. The second operation took place at MET 2/21:49:10 and lasted for 10.01 hours. The PRM had no anomalous behavior during either operation.

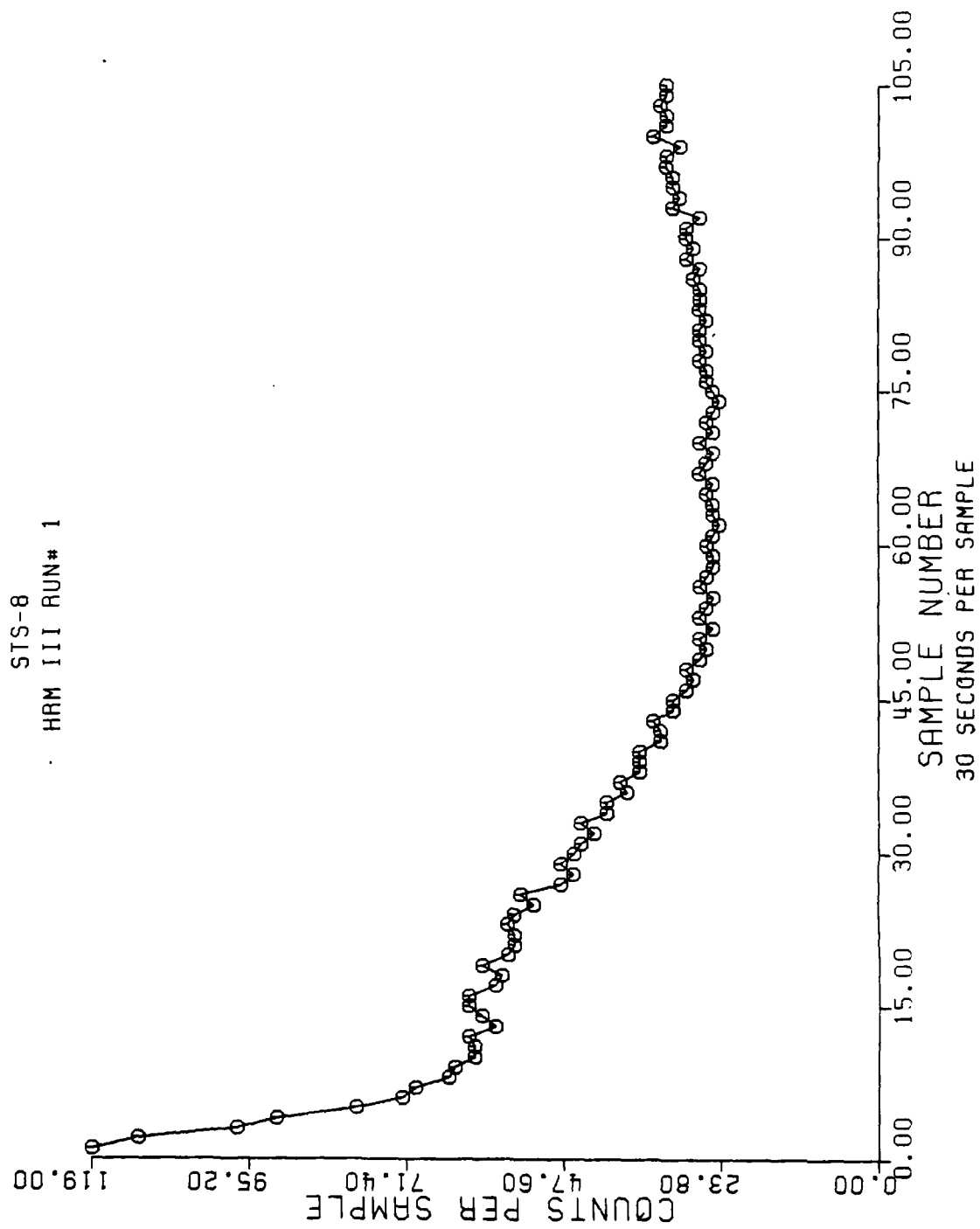
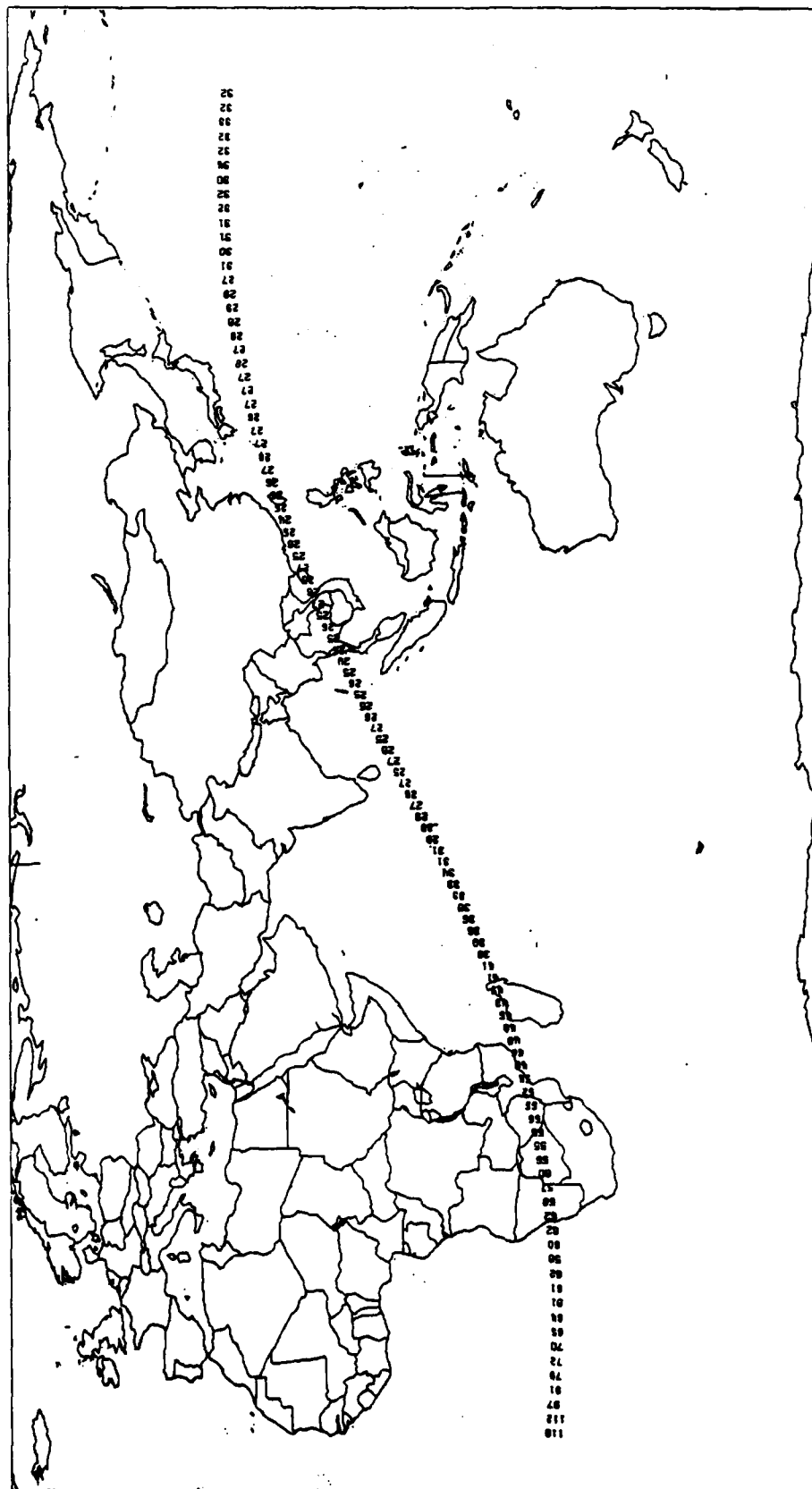


Figure 3

OPERATION NO. 1



**8-515**

### Figure 4



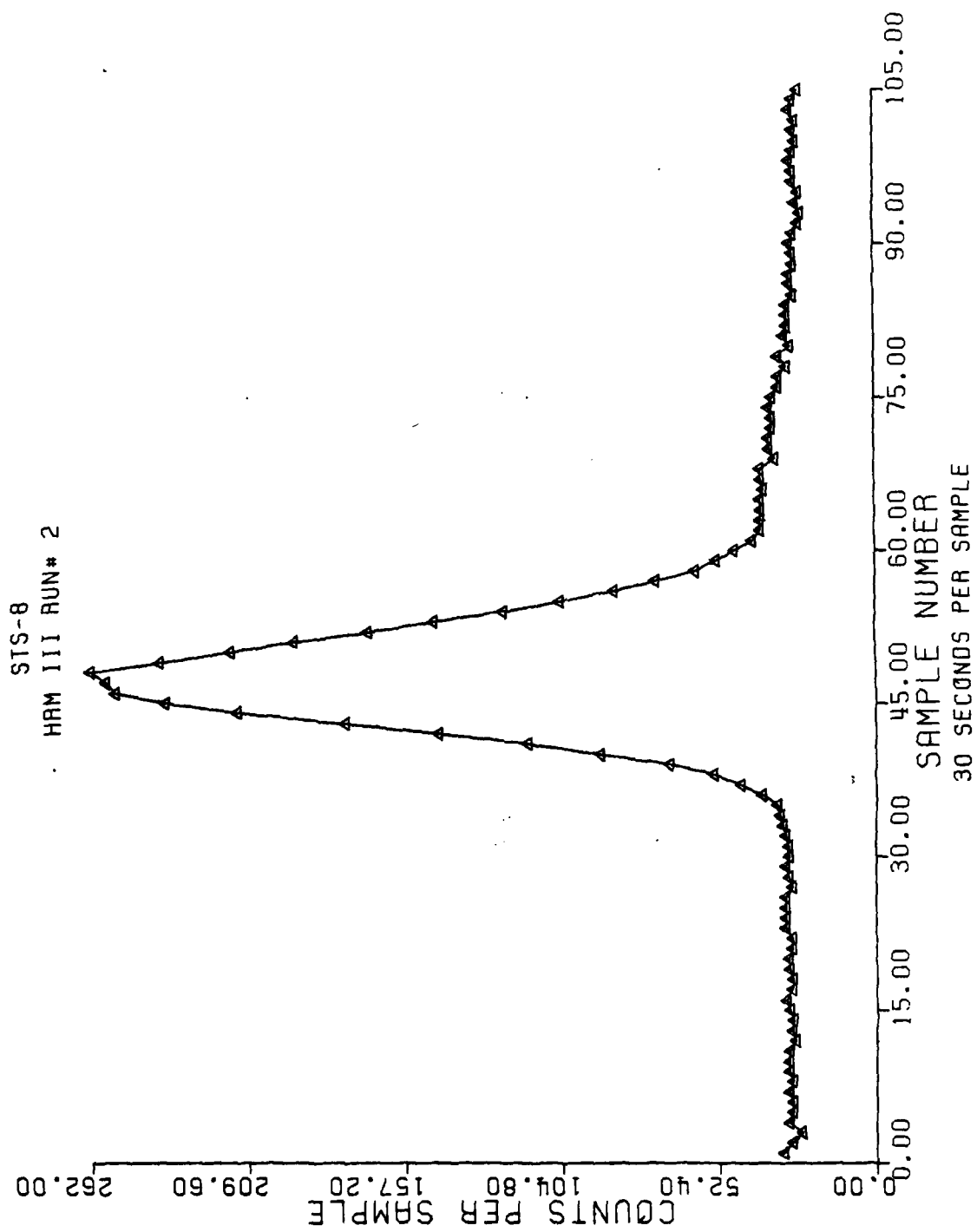
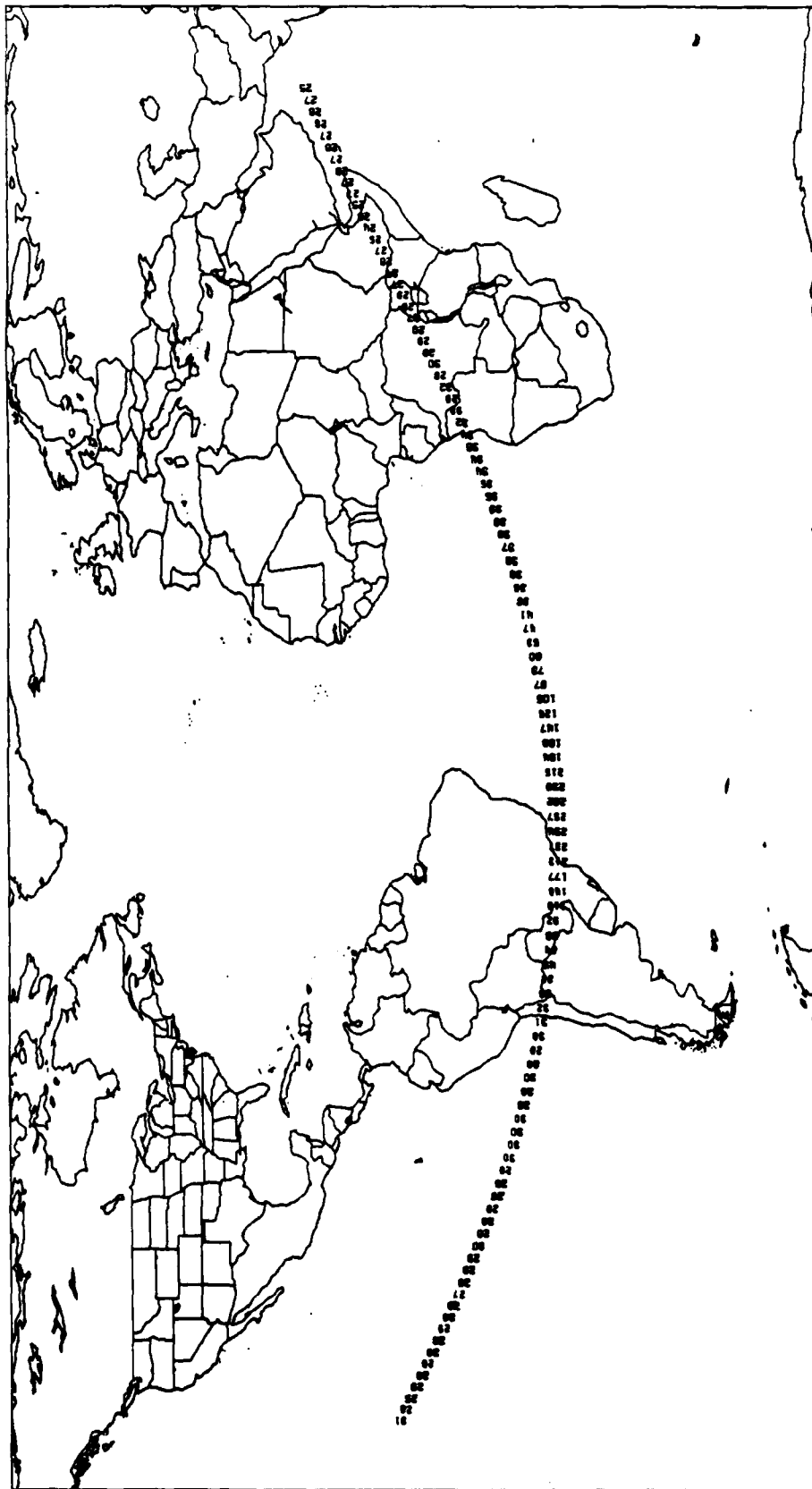


Figure 5

HRM-111

OPERATION NO. 2



ST5-8

Figure 6

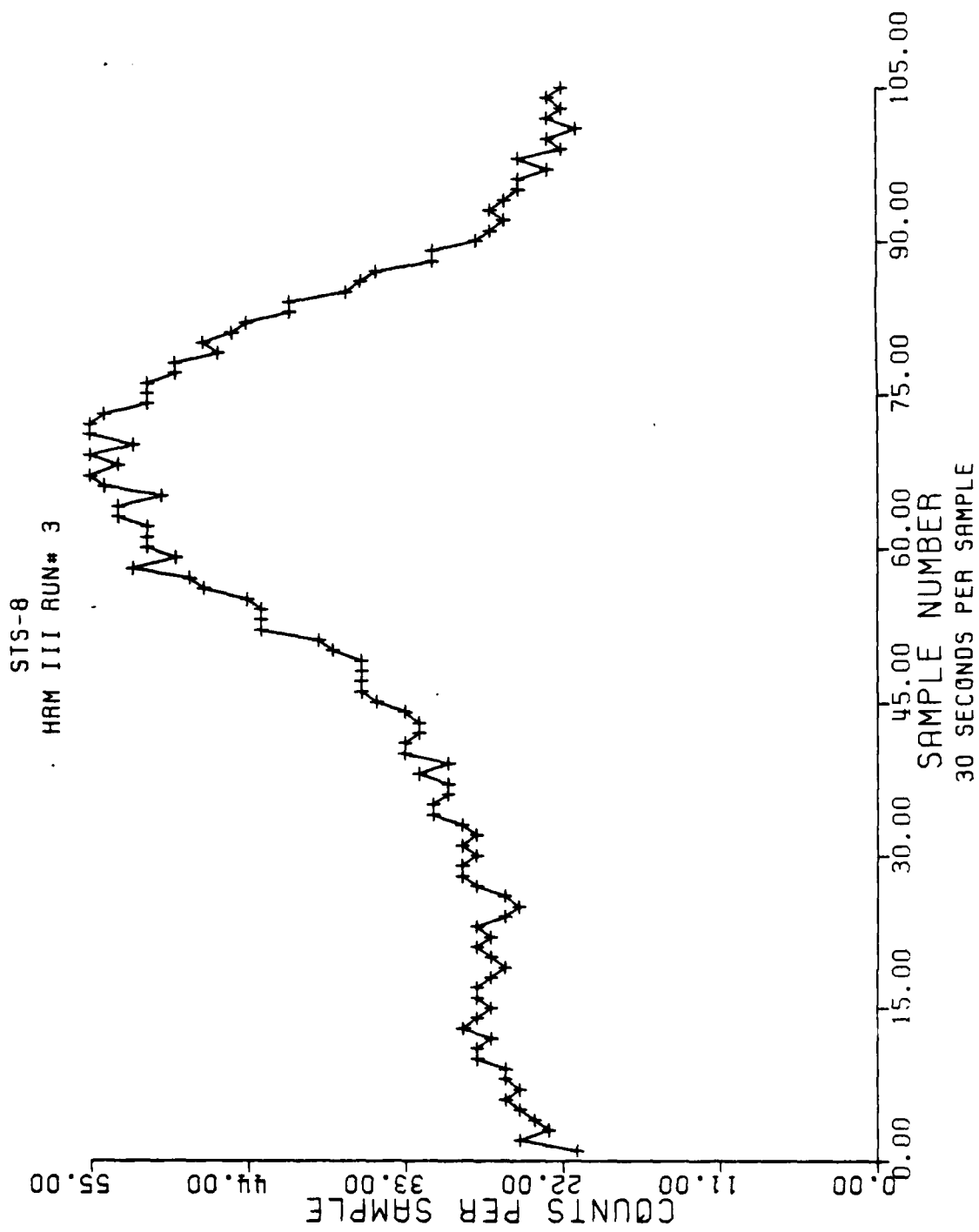
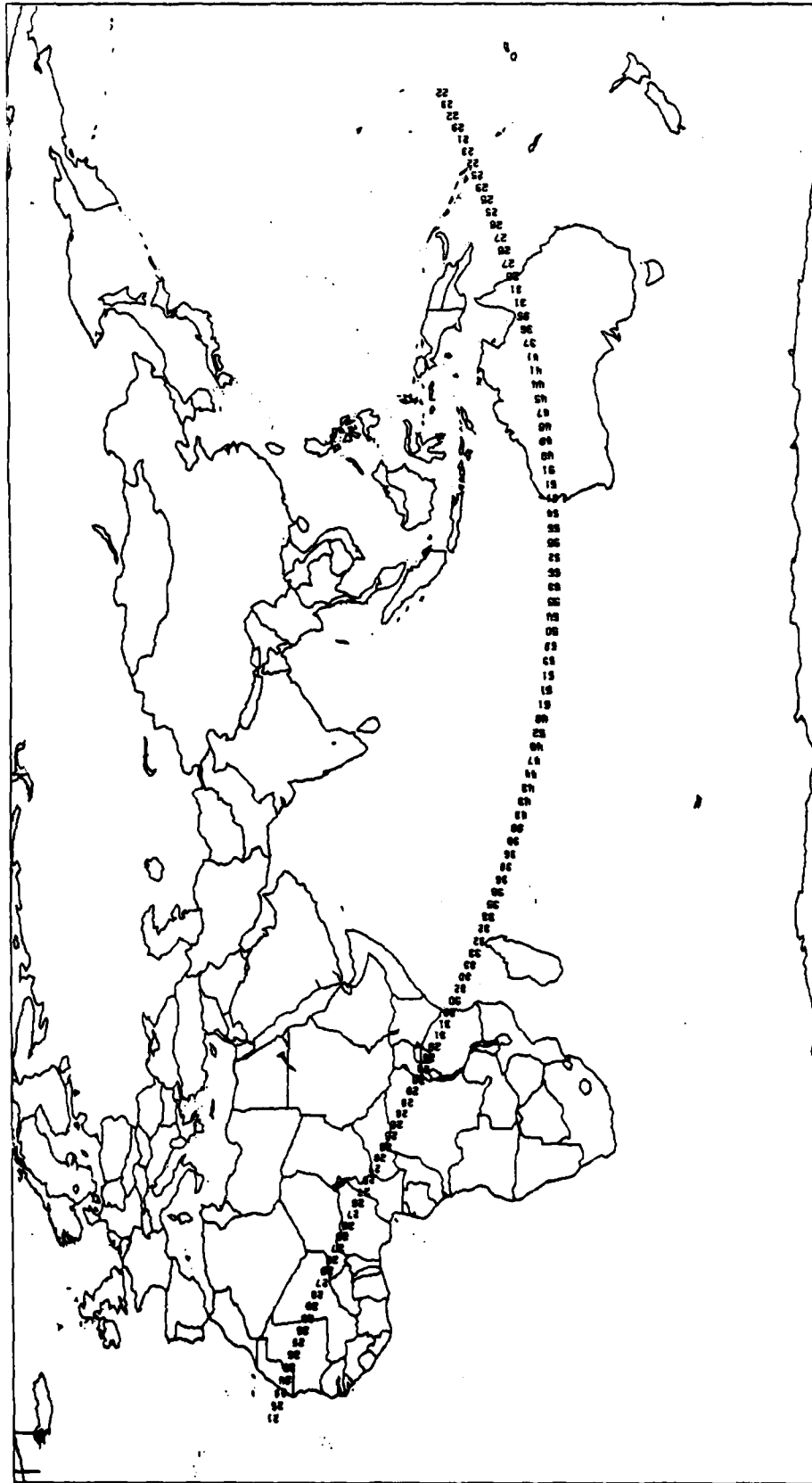


Figure 7

HAM-111

OPERATION NO. 3



STS-8

Figure 8

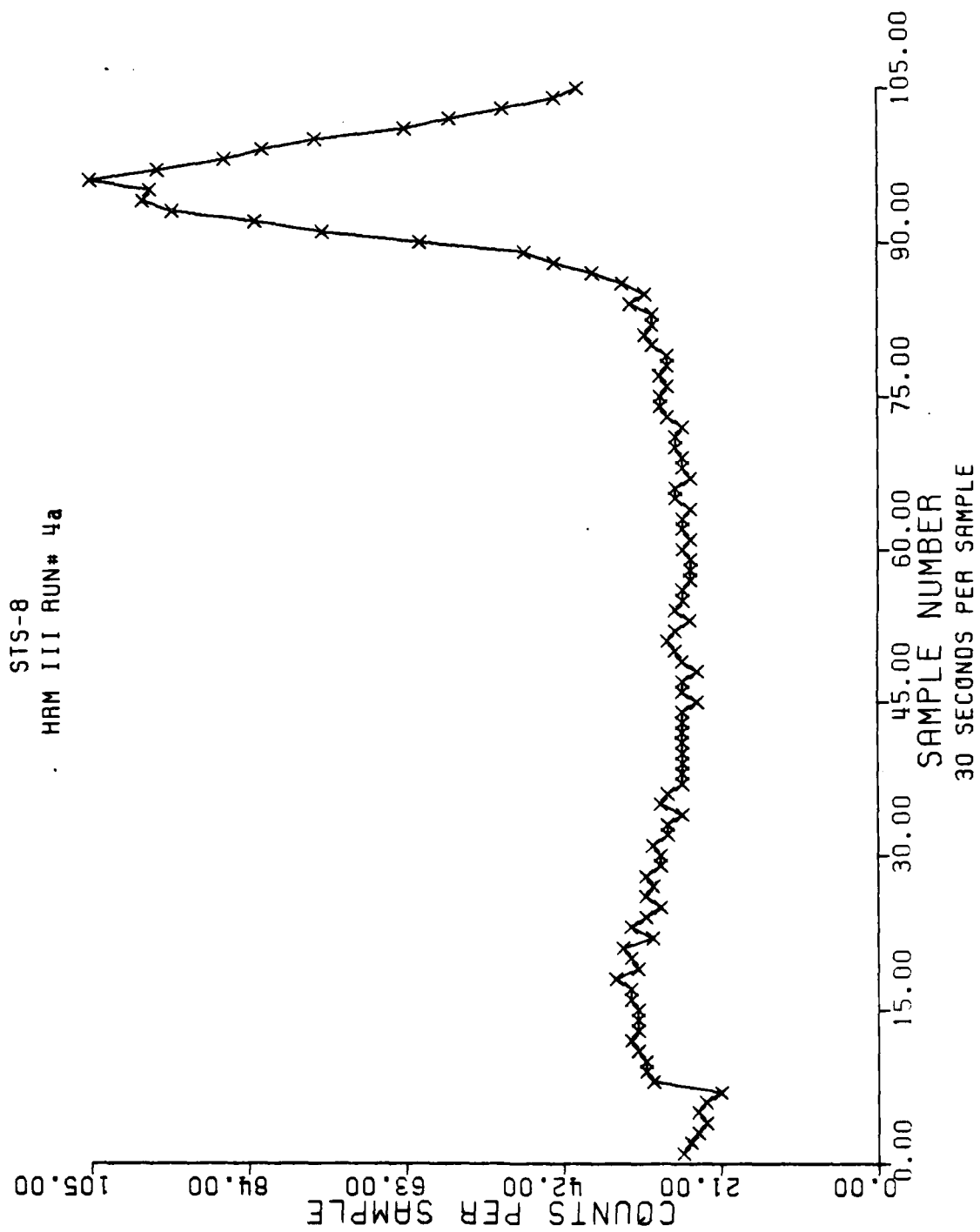
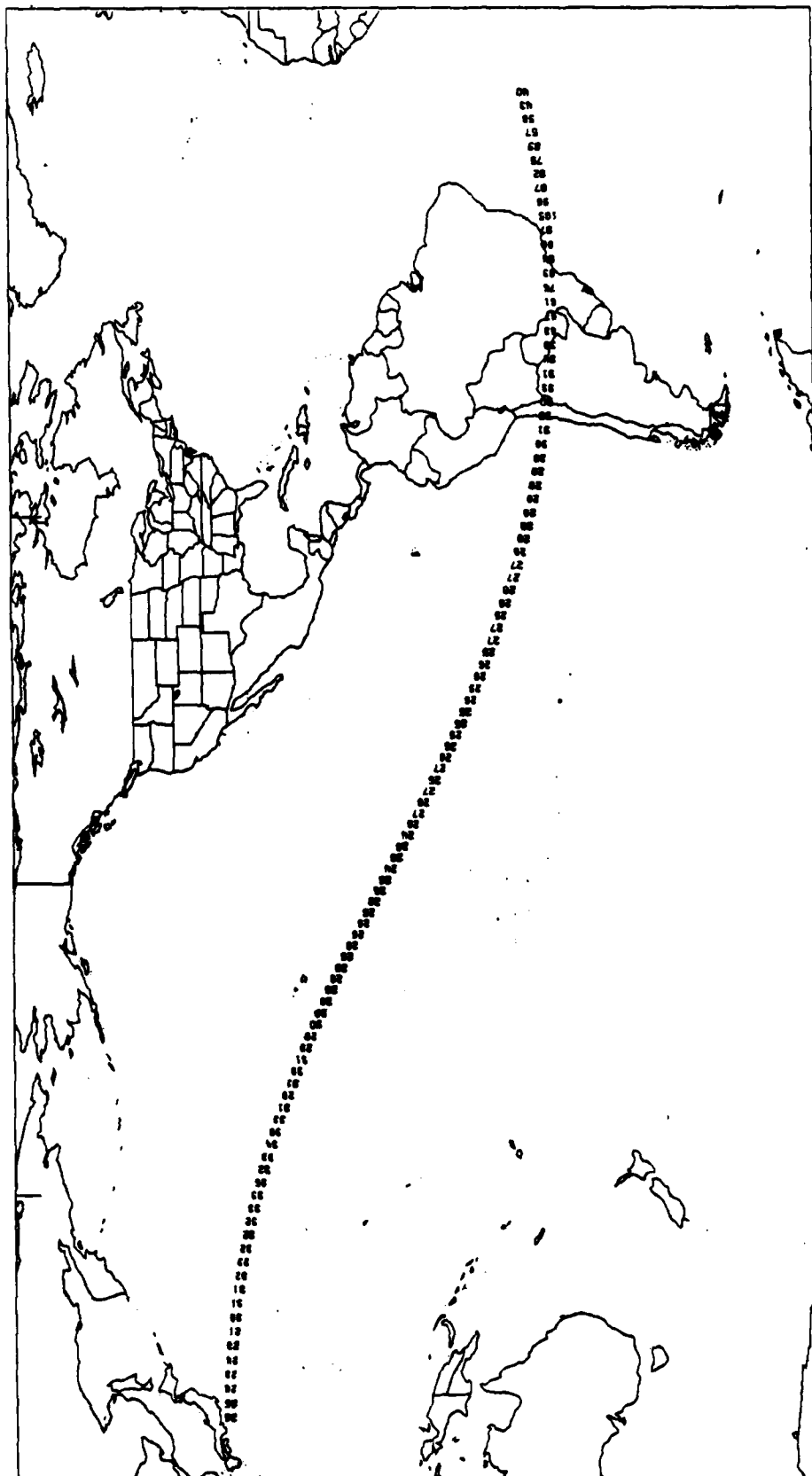


Figure 9

HRM-III

OPERATION NO. 4a



STS-8

Figure 10

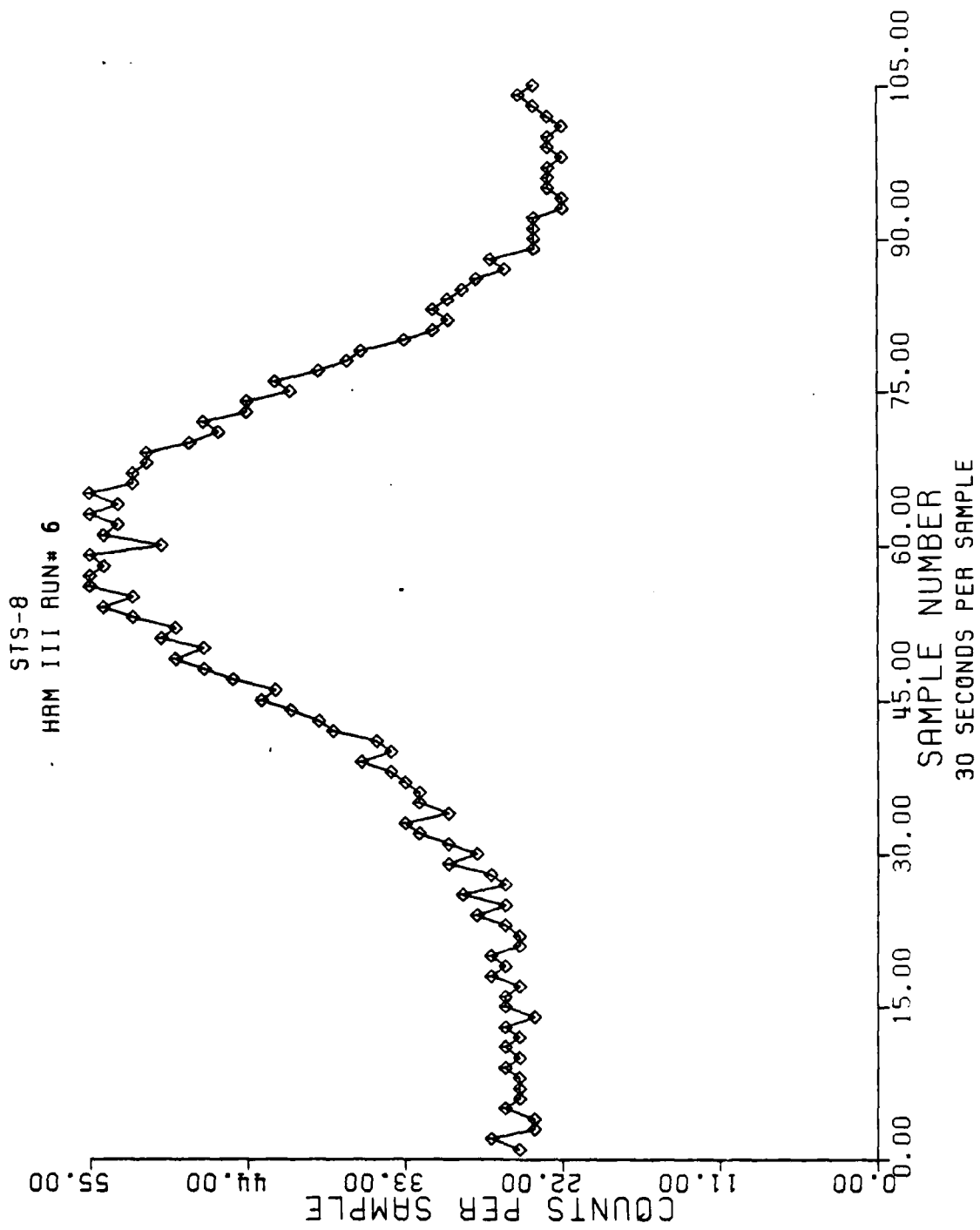
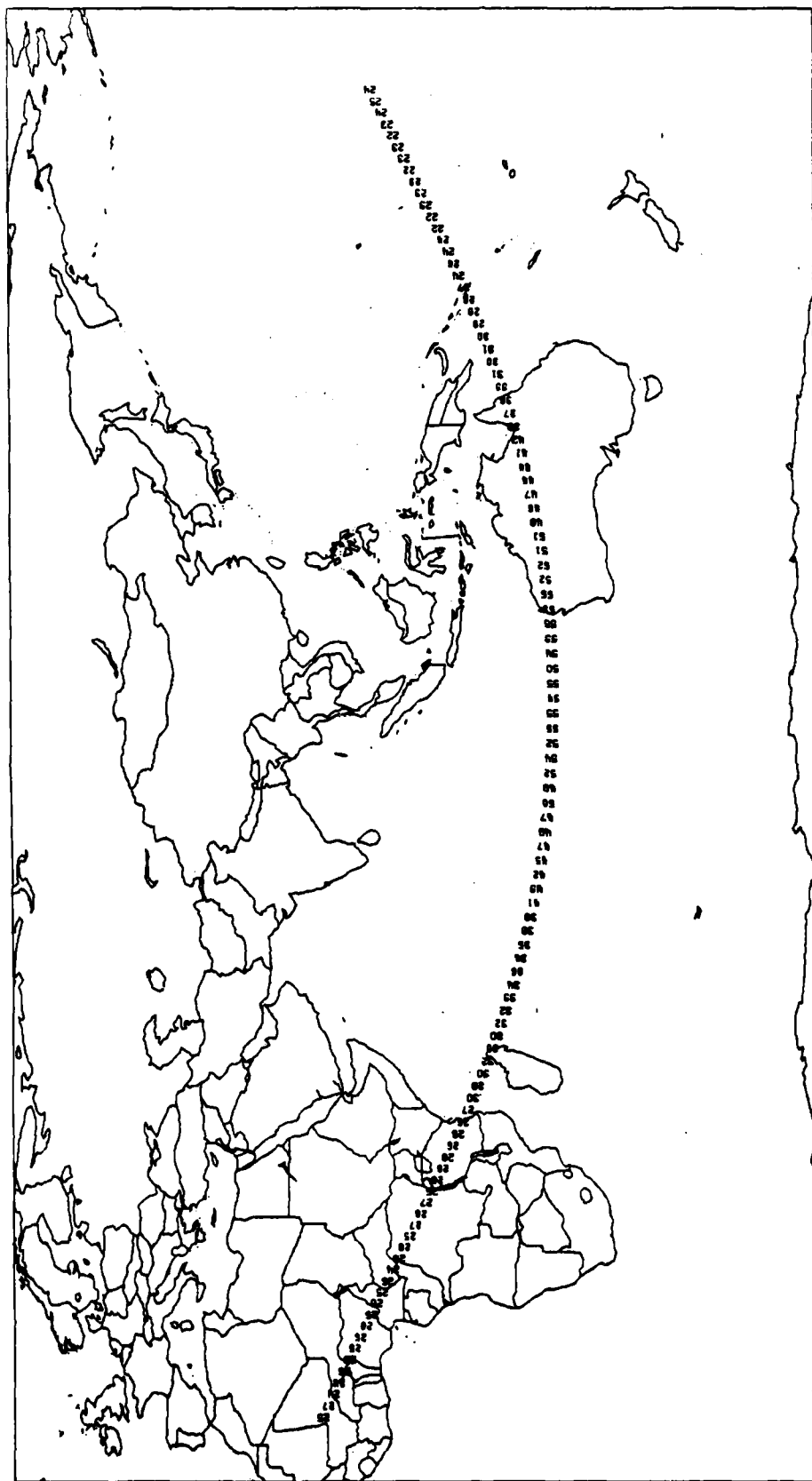


Figure 11

HRM-III

OPERATION NO. 6



STS-8

Figure 12



STS-8  
HAM III RUN# 7

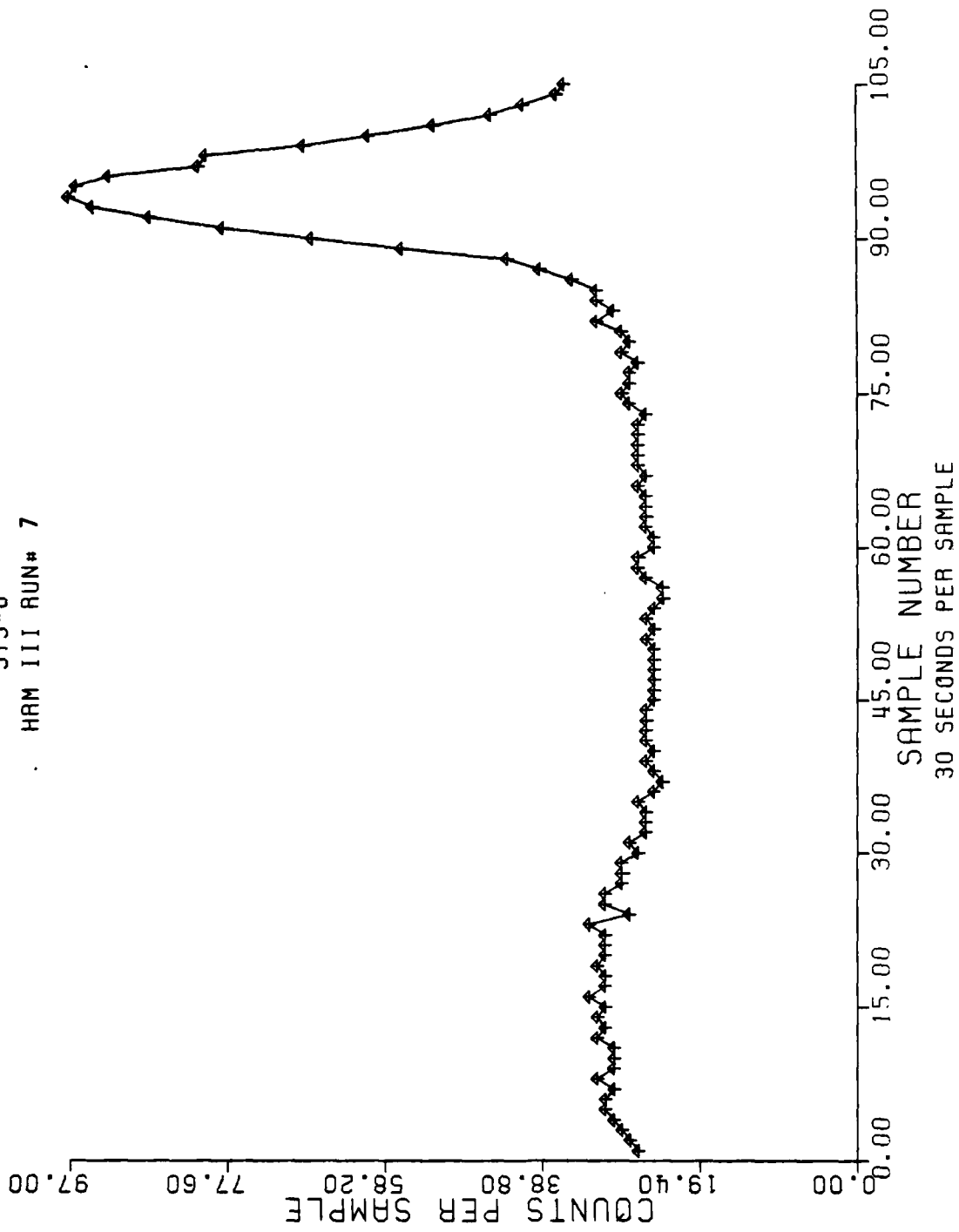
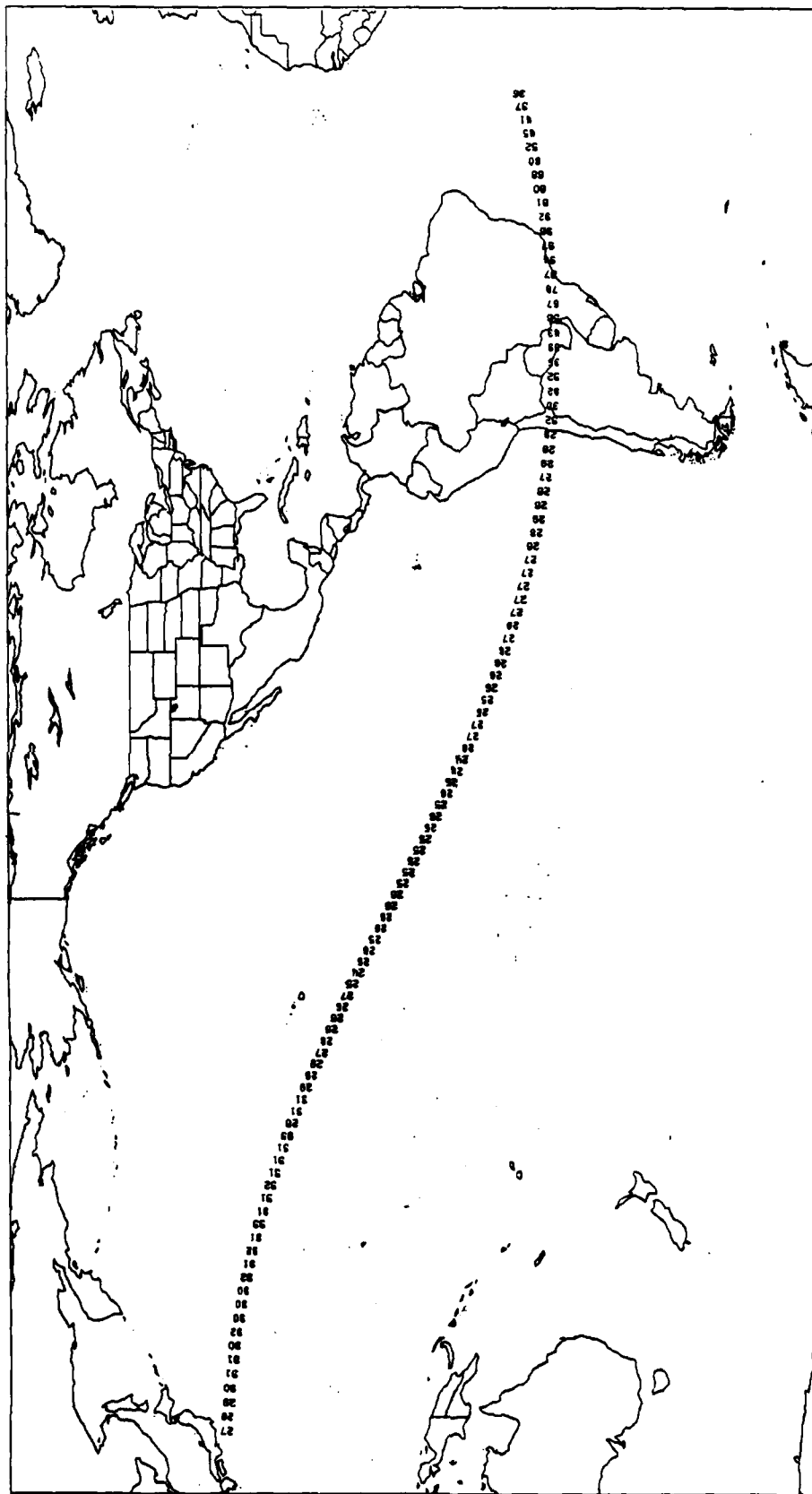


Figure 13

HAM-111

OPERATION NO. 7



ST5-8

Figure 14

STS-8  
HRM III RUN# 8

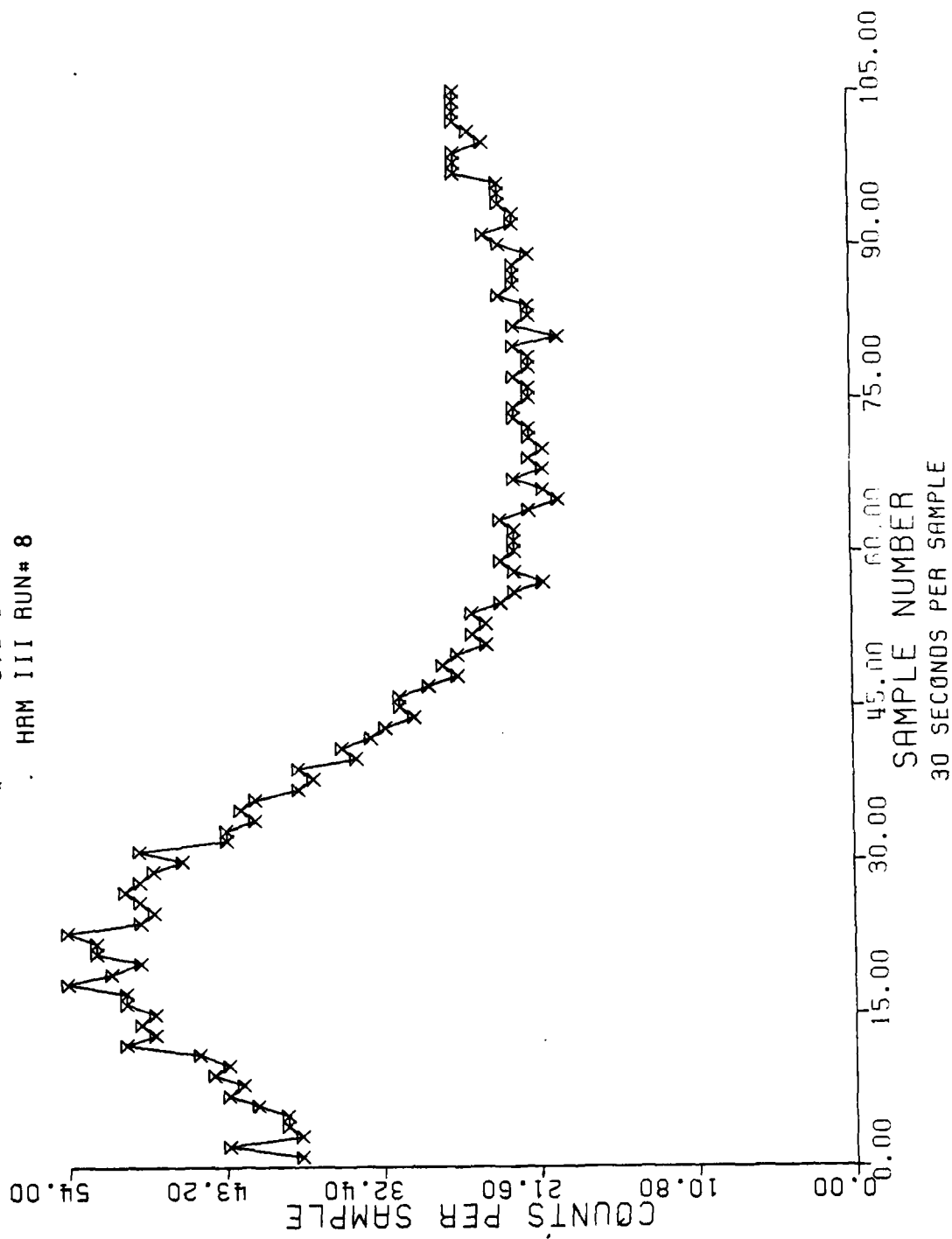
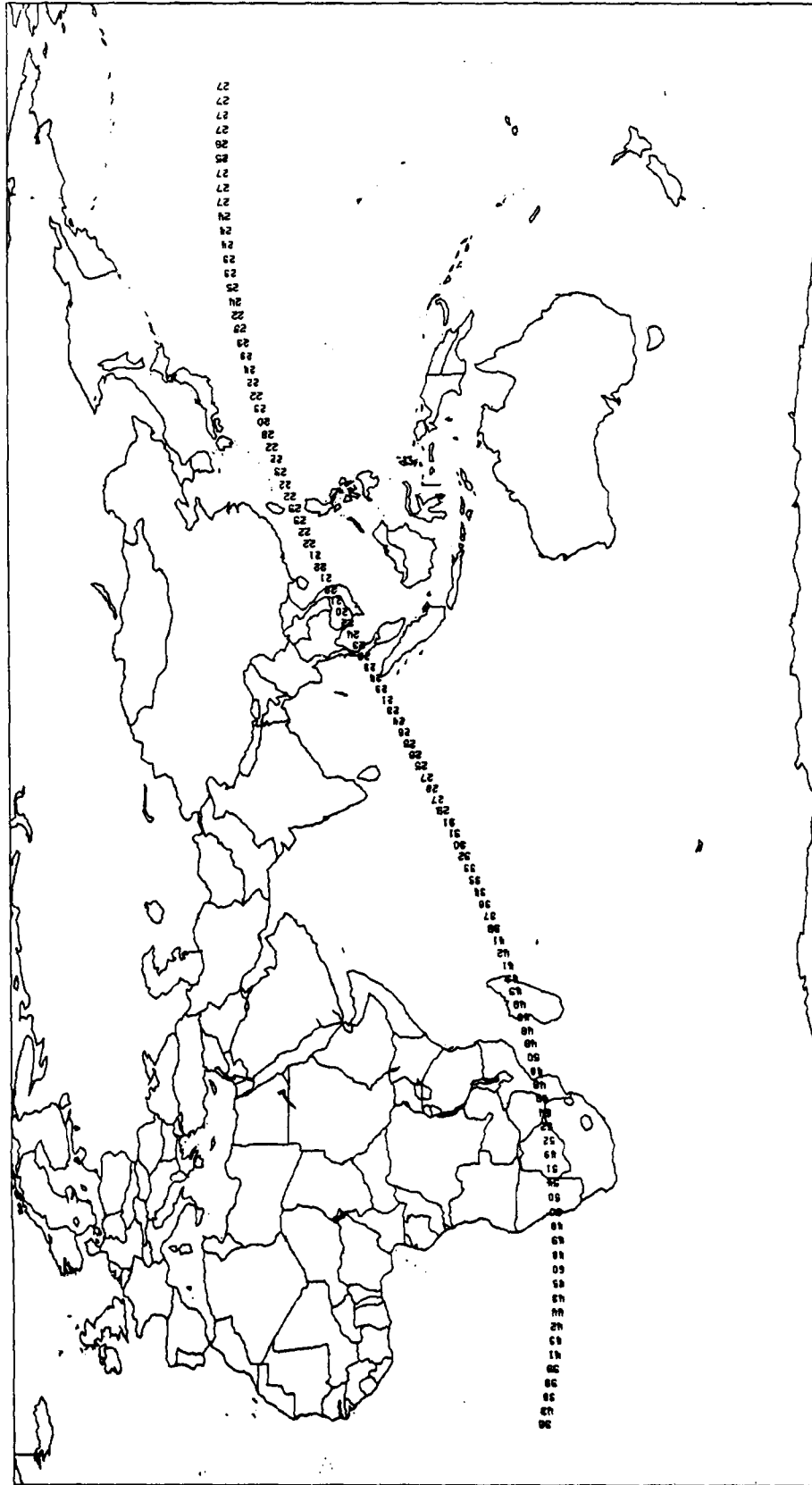


Figure 15

HRM-III

OPERATION NO. 8



STS-8

Figure 16

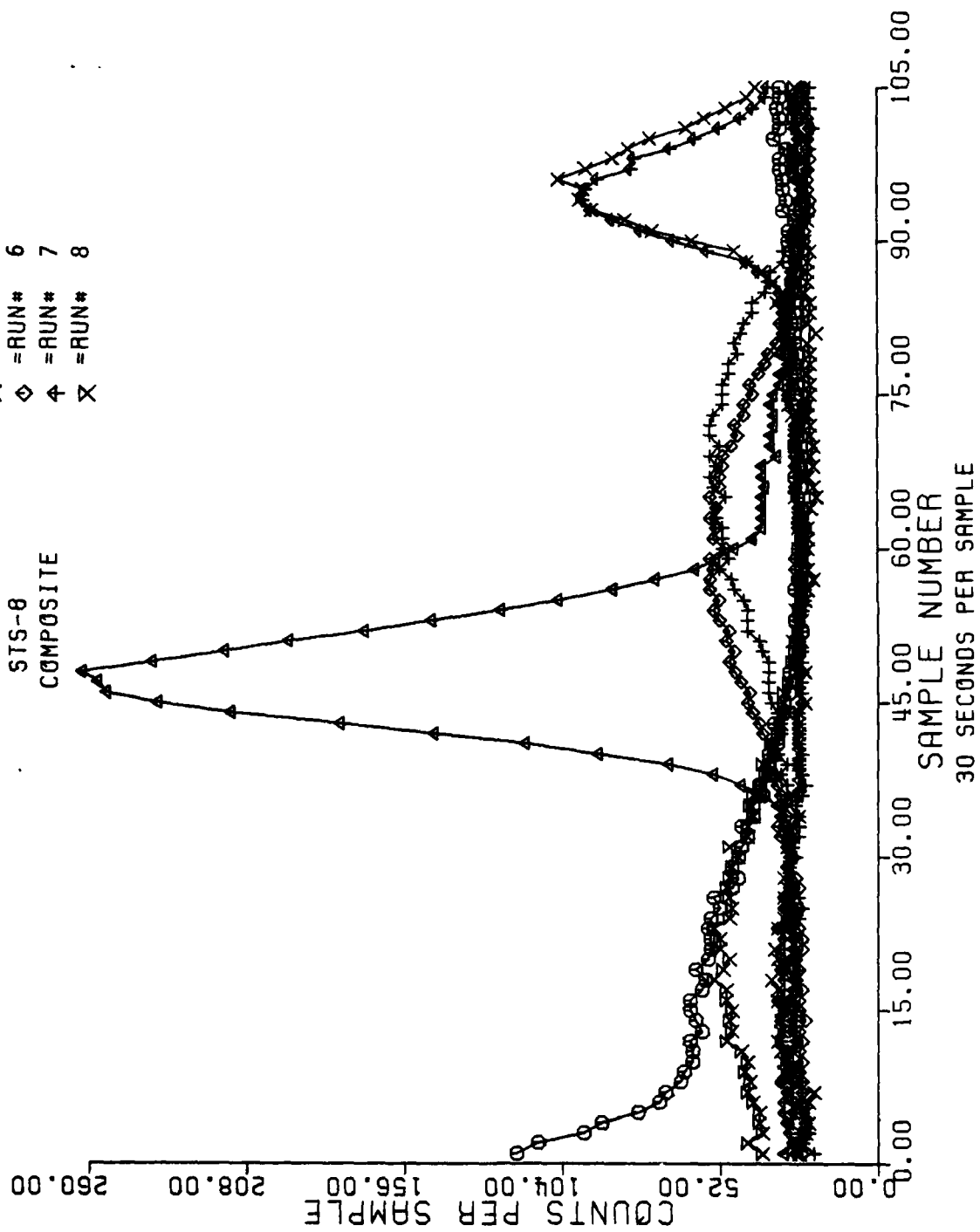


Figure 17

PRM data is presented in Table 1. The count rate is approximately the same for both operations. Table 2 shows the average dose rate for each operation and the average dose rate for both operations combined. For a seven day mission (more exactly 7 days, 1 hour, 39 minutes), this would predict a dosage from neutrons and protons to be 53.02m REM or 4.22m RAD. These are much lower than NASA values (ref 4) since gamma-ray dosage is not included.

PRM calibration (ref 1) was performed by EG&G in May of 1983. The PRM was found to be accurate to within 3% during this calibration.

TABLE 1

PRM DATA FROM STS-8

RAW DATA

| MET                      | 1/07:10:57           | 2/21:49:10           |
|--------------------------|----------------------|----------------------|
| Counts                   | 1340                 | 826                  |
| Average<br>Count<br>Rate | 86.79/hr             | 82.52/hr             |
| Stdr<br>Dev              | $\pm 9.32/\text{hr}$ | $\pm 9.08/\text{hr}$ |
| rem                      | 4.96 mrem            | 3.04 mrem            |
| rad                      | .398 mrad            | .240 mrad            |
| Hours                    | 15.44 hrs            | 10.01 hrs            |

TABLE 2

PRM DATA FROM STS-8

AVERAGE DOSE RATES

| MEI                    | 1/07:10:57 | 2/21:49:10 |
|------------------------|------------|------------|
| Dose Rate<br>(mrem/hr) | .321       | .304       |
| Dose Rate<br>(mrad/hr) | .0258      | .0240      |

Average dose rate for both operations:

(mrem/hr)  $.3125 \pm .012$

(mrad/hr)  $.0249 \pm .0013$



## SECTION IV

### CONCLUSIONS

The data collected from the RME are consistent with data taken on previous missions. There were no surprises in the data and any variations in the data correspond to natural external sources of radiation (e.g., the South Atlantic Anomaly).

The procedures used for the RME on STS-8 allowed the crew to employ the full capability of both instruments. Thus, the objective of testing the feasibility of using non-space specific hardware in space was adequately demonstrated. An important point to note here is that the instruments were easily operated and read by the crew and meaningful data were obtained. These instruments are also easily serviced by the crew. The second objective of obtaining radiation background data was also satisfied by this mission.

Future flights of the RME will contribute to the data base on background radiation. Different mission profiles will yield data from different altitudes and orbital inclination. Such a data base will prove useful for planning future space systems, including crew health and safety requirements as may exist in permanently inhabited stations and platforms.

#### REFERENCES

1. STS-6 Report, (in publishing), AFTAC, Caplan et al.
2. HRM-III Handheld Radiation Monitor User's Handbook; EG&G Report No. EGGH83-2424 S-347-PW, June 1981
3. Pocket Neutron REM Meter; W. Quam, T. DeDuca et al, preprint, February 1980
4. Flight Note to Flight Surgeon from Radiation, STS-8, Flight Day #6, 4 Sep 83. The flight note places an estimate of the total mission dosage to be 45mrads.

**APPENDIX A**

**RAW DATA**

# FOR WHEATCRAFT

## PRM OPS

### 1 ACTIVATION & CHECKOUT

Unstow PRM

If second operation, replace, mark, and stow used battery

Set Rotary sw - IRS

ON/OFF sw - ON

✓ Display counts down from 9999 and record MET on PRM DATA PAD when Display = 0.00

- \* If display shows a colon or is \*
- \* blank, set ON/OFF sw - OFF; \*
- \* replace, mark, and stow used \*
- \* battery and repeat step 1 \*

Report MET to MCC

Restow PRM (leave ON)

### 2 DATA RECORDING

8-12 hrs after step 1, unstow PRM

Set rotary switch to appropriate positions and record display outputs on PRM DATA PAD

Set ON/OFF sw - OFF

Stow PRM

#### PRM DATA PAD

|                            |                       |                      |
|----------------------------|-----------------------|----------------------|
| 0.00 MET <u>1/07:10:57</u> |                       | <u>2/21:49:10</u>    |
| HRS                        | <u>15.44</u>          | <u>10.01</u>         |
| CNTS                       | <u>1.340-E (+) 03</u> | <u>.826 E (+) 03</u> |
| RAU                        | <u>3.98 E (-) 04</u>  | <u>2.40 E (-) 04</u> |
| REM                        | <u>4.96 E (-) 03</u>  | <u>3.04 E (-) 03</u> |

FS 3-9

STS-C/FIN A

DATA PAD FOR THE

PRM

Run 1

2 52/05 28:00

HRM DATA PADS

| CANAL | SENT/SEC | CANAL | CNTS/SEC | CANAL | CNTS/SEC | CANAL | CNTS/SEC | CANAL | CNTS/SEC |
|-------|----------|-------|----------|-------|----------|-------|----------|-------|----------|
| 0-1   | 119      | 0-22  | 55       | 0-13  | 34       | 0-61  | 25       | 0-15  | 27       |
| 0-2   | 112      | 0-23  | 56       | 0-14  | 31       | 0-62  | 26       | 0-16  | 28       |
| 0-3   | 97       | 0-24  | 55       | 0-15  | 31       | 0-63  | 35       | 0-17  | 27       |
| 0-4   | 91       | 0-25  | 52       | 0-16  | 29       | 0-64  | 26       | 0-18  | 29       |
| 0-5   | 79       | 0-26  | 54       | 0-17  | 28       | 0-65  | 26       | 0-19  | 28       |
| 0-6   | 72       | 0-27  | 48       | 0-18  | 29       | 0-66  | 25       | 0-20  | 29       |
| 0-7   | 70       | 0-28  | 46       | 0-19  | 27       | 0-70  | 27       | 0-21  | 29       |
| 0-8   | 65       | 0-29  | 48       | 0-20  | 26       | 0-71  | 25       | 0-22  | 27       |
| 0-9   | 64       | 0-30  | 46       | 0-21  | 27       | 0-72  | 26       | 0-23  | 31       |
| 0-10  | 61       | 0-31  | 45       | 0-22  | 25       | 0-73  | 25       | 0-24  | 30       |
| 0-11  | 61       | 0-32  | 43       | 0-23  | 27       | 0-74  | 24       | 0-25  | 31       |
| 0-12  | 62       | 0-33  | 45       | 0-24  | 26       | 0-75  | 25       | 0-26  | 31       |
| 0-13  | 58       | 0-34  | 41       | 0-25  | 25       | 0-76  | 26       | 0-27  | 32       |
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| 0-21  | 55       | 0-42  | 33       | 0-33  | 25       | 0-84  | 27       | 0-35  | 32       |

FS 3-5

DATA PAD FOR THE  
HRM-III  
OPERATION 1

100

**WUW DAY PADS**

40

ST-3/7: A

20

Run #3

1/3

21

1411 HET 21:30:00 HRM-III TABS

| CHANEL | COMPS/SEC | CHANEL | COMPS/SEC | CHANEL | COMPS/SEC | CHANEL | COMPS/SEC | CHANEL | COMPS/SEC | CHANEL | COMPS/SEC |
|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|
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| 0-5    | 25        | 0-26   | 26        | 0-47   | 36        | 0-68   | 53        | 0-89   | 27        | 0-110  | 26        |
| 0-6    | 26        | 0-27   | 28        | 0-48   | 36        | 0-69   | 52        | 0-90   | 26        | 0-111  | 27        |
| 0-7    | 25        | 0-28   | 29        | 0-49   | 38        | 0-70   | 55        | 0-91   | 27        | 0-112  | 26        |
| 0-8    | 26        | 0-29   | 29        | 0-50   | 39        | 0-71   | 54        | 0-92   | 25        | 0-113  | 25        |
| 0-9    | 26        | 0-30   | 28        | 0-51   | 43        | 0-72   | 51        | 0-93   | 23        | 0-114  | 23        |
| 0-10   | 28        | 0-31   | 29        | 0-52   | 43        | 0-73   | 49        | 0-94   | 22        | 0-115  | 23        |
| 0-11   | 28        | 0-32   | 28        | 0-53   | 44        | 0-74   | 47        | 0-95   | 23        | 0-116  | 23        |
| 0-12   | 27        | 0-33   | 31        | 0-54   | 47        | 0-75   | 49        | 0-96   | 22        | 0-117  | 23        |
| 0-13   | 29        | 0-34   | 30        | 0-55   | 51        | 0-76   | 46        | 0-97   | 23        | 0-118  | 22        |
| 0-14   | 28        | 0-35   | 31        | 0-56   | 49        | 0-77   | 47        | 0-98   | 23        | 0-119  | 23        |
| 0-15   | 27        | 0-36   | 30        | 0-57   | 52        | 0-78   | 45        | 0-99   | 22        | 0-120  | 22        |
| 0-16   | 28        | 0-37   | 30        | 0-58   | 51        | 0-79   | 41        | 0-100  | 23        | 0-121  | 23        |
| 0-17   | 28        | 0-38   | 31        | 0-59   | 51        | 0-80   | 41        | 0-101  | 22        | 0-122  | 22        |
| 0-18   | 27        | 0-39   | 30        | 0-60   | 51        | 0-81   | 41        | 0-102  | 23        | 0-123  | 22        |
| 0-19   | 26        | 0-40   | 33        | 0-61   | 51        | 0-82   | 41        | 0-103  | 23        | 0-124  | 22        |
| 0-20   | 27        | 0-41   | 33        | 0-62   | 53        | 0-83   | 41        | 0-104  | 22        | 0-125  | 22        |
| 0-21   | 28        | 0-42   | 32        | 0-63   | 53        | 0-84   | 41        | 0-105  | 22        | 0-126  | 22        |

FS 3-7

STS-2/FIN A

DATA PAD FOR THE  
HRM-III  
OPERATION 3







5074 Y1P0 X8M

1111 1113/21:19.00

[illegible]

FS 3-G  
FS 3-8

STC-27 IN A  
SIS-27 IN A

4/07/i6+00

STC-2/FIN: A  
STC-2/FIN: A

33

Run A8

NEW DATA PADS

INIT NEW 5163:15:00

| COUNT | CO-NT-SEC | COUNT | CO-NT-SEC | COUNT | CO-NT-SEC | COUNT | CO-NT-SEC | COUNT | CO-NT-SEC |
|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|
| 0-1   | 38        | 0-11  | 52        | 0-11  | 32        | 0-11  | 22        | 0-11  | 19        |
| 0-2   | 43        | 0-12  | 54        | 0-11  | 30        | 0-11  | 20        | 0-11  | 23        |
| 0-3   | 38        | 0-13  | 49        | 0-11  | 31        | 0-11  | 21        | 0-11  | 23        |
| 0-4   | 39        | 0-14  | 48        | 0-11  | 31        | 0-11  | 23        | 0-11  | 23        |
| 0-5   | 39        | 0-15  | 49        | 0-11  | 29        | 0-11  | 21        | 0-11  | 22        |
| 0-6   | 41        | 0-16  | 50        | 0-11  | 27        | 0-11  | 22        | 0-11  | 24        |
| 0-7   | 43        | 0-17  | 49        | 0-11  | 28        | 0-11  | 21        | 0-11  | 25        |
| 0-8   | 42        | 0-18  | 48        | 0-11  | 27        | 0-11  | 22        | 0-11  | 23        |
| 0-9   | 44        | 0-19  | 46        | 0-11  | 25        | 0-11  | 22        | 0-11  | 23        |
| 0-10  | 43        | 0-20  | 49        | 0-11  | 26        | 0-11  | 23        | 0-11  | 24        |
| 0-11  | 45        | 0-21  | 43        | 0-11  | 25        | 0-11  | 23        | 0-11  | 24        |
| 0-12  | 50        | 0-22  | 43        | 0-11  | 26        | 0-11  | 22        | 0-11  | 24        |
| 0-13  | 48        | 0-23  | 41        | 0-11  | 24        | 0-11  | 22        | 0-11  | 27        |
| 0-14  | 49        | 0-24  | 42        | 0-11  | 23        | 0-11  | 23        | 0-11  | 27        |
| 0-15  | 48        | 0-25  | 41        | 0-11  | 23        | 0-11  | 22        | 0-11  | 27        |
| 0-16  | 50        | 0-26  | 38        | 0-11  | 21        | 0-11  | 22        | 0-11  | 25        |
| 0-17  | 50        | 0-27  | 37        | 0-11  | 23        | 0-11  | 23        | 0-11  | 26        |
| 0-18  | 54        | 0-28  | 38        | 0-11  | 24        | 0-11  | 20        | 0-11  | 27        |
| 0-19  | 51        | 0-29  | 34        | 0-11  | 23        | 0-11  | 23        | 0-11  | 27        |
| 0-20  | 49        | 0-30  | 35        | 0-11  | 23        | 0-11  | 22        | 0-11  | 27        |
| 0-21  | 52        | 0-31  | 33        | 0-11  | 24        | 0-11  | 22        | 0-11  | 27        |

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OPERATION 8

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